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Review

Intervening to change behaviour and save energy in the workplace: A systematic review of available evidence

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ABSTRACT

Workplaces worldwide are a major source of carbon emissions and changing energy use behaviour in these environments has the capacity for large carbon savings. This paper reviews and synthesises empirical evidence to identify what types of behaviour change intervention are most successful at saving energy in an office-type workplace. We draw on the field of health-related behaviour change interventions and adopt the Behaviour Change Wheel (Michie et al., 2014) as a framework through which to assess the success of the interventions reviewed here (n = 22 studies). We find that interventions creating social and physical opportunities for employees to save energy are the most successful i.e. which constitute Enablement (including direct support and greater control to employees), Environmental Restructuring (particularly automated and retrofitted technologies) and Modelling (various forms of social influence). The communal nature of most workplaces demands scrutiny to understand the effect of social influences. We provide recommendations for future research, including the need to consider forms of intervention not yet researched; Coercion, Restriction, and Training. We conclude by calling for further, well evaluated, energy saving behavioural interventions in a variety of workplaces to identify those techniques which offer the greatest success in saving energy and thus reducing carbon emissions.

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Contents

1. Introduction 31
   1.1. Energy conservation in domestic settings vs. the workplace 31
   1.2. Pro-environmental behaviour & behaviour change 32
   1.3. In the workplace: pro-environmental behaviour & energy-use behaviour change 32
   1.4. Behaviour change framework 33
2. Methodology 34
   2.1. Systematic review procedures 34
      2.1.1. Eligibility criteria 34
      2.1.2. Systematic search methodology 35
      2.1.3. Assessment of validity 35
      2.1.4. Systematic presentation 35
   2.2. Overview of the reviewed interventions 35
3. Intervening in energy use behaviours in the workplace: a synthesis of available evidence to date 36
   3.1. The success of different forms of intervention 36
      3.1.1. Education 36
      3.1.2. Persuasion 37
      3.1.3. Incentivisation 37

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3.1.4. Coercion ... 38
3.1.5. Training ... 38
3.1.6. Restriction ... 38
3.1.7. Environmental restructuring ... 38
3.1.8. Modelling ... 39
3.1.9. Enablement ... 40
3.1.10. Summary of intervention success ... 40
3.2. The importance of different 'Sources of Behaviour' ... 41
4. Discussion ... 41
4.1. Saving energy in the workplace ... 41
4.2. Methodological considerations ... 41
4.3. Recommendations for future research ... 42
5. Conclusions ... 42
Acknowledgements ... 43
Appendix A. Systematic review process ... 43
Choice of base keywords ... 43
ET (energy terms) ... 43
WT (workplace terms) ... 43
Choice of combination keywords ... 43
BT (behaviour terms) ... 43
ES (energy systems) ... 43
ST (social terms) & PV (personal variables) ... 43
Formulation of queries ... 43
Applying Inclusion and Exclusion Criteria ... 43
Appendix B. Brief introduction to the 22 studies reviewed in this paper ... 45
Appendix C. Details of the studies reviewed in this paper according to the Intervention Functions of the Behaviour Change Wheel (definitions are given below; Michie et al., 2014, p.111 [53]) ... 48
References ... 50

1. Introduction

Non-domestic buildings currently account for around 18% of UK carbon emissions [1] and 20% globally [2]; figures which are set to increase in the future, making workplaces an important focus for energy efficiency and energy saving initiatives around the world. Various mechanisms exist to promote energy reductions in non-domestic settings, from voluntary agreements (VAs), adoption of Energy and Environmental Management Systems (EMS), energy audits, use of energy efficient technologies, and occupant engagement [3]. In this paper we focus on the latter of these options, namely interventions in the workplace which aim to change employee behaviour and by doing so, save energy. Literature on this subject is currently sparse and is dispersed across a number of academic disciplines, thus findings need to be integrated to enable key learnings to be identified [3] and to allow appropriate and effective policy and practice to be put in place to promote energy saving in the non-domestic sector [4]. This paper directly addresses this need by conducting a systematic review of empirical studies worldwide (though restricted to those published in English) to identify the interventions that are most successful at saving energy in the workplace; we also identify and discuss future research needs. Every effort has been made to include all studies published by the end of 2015, although we note that the field is expanding rapidly and some literature in this field is difficult to access and often not indexed (e.g. third sector reports). As with all reviews, those interested in the rich contextual details contained in the original studies are encouraged to consult those directly. Presented here is a high-level and systematic analysis which identifies the trends and gaps in currently available evidence on an international basis.

Below we provide a brief review of energy conservation in domestic settings and pro-environmental behaviour more broadly, before turning to energy use in the workplace. We then describe the framework used to analyse the studies reviewed in this paper.

1.1. Energy conservation in domestic settings vs. the workplace

Significant headway has been made in understanding energy use in a *domestic* setting. A review of interventions aimed at household energy conservation by social and environmental psychologists reveals that most focus on voluntary behaviour change, rather than changing contextual factors (for example the use of energy efficient equipment) [5]. Interventions reviewed include the provision of information, feedback and rewards, all of which aim to change individuals' knowledge and perceptions of energy saving activities. The review finds that information produces higher levels of knowledge but not necessarily changes in behaviour; that rewards are generally effective in generating energy savings but that these can be short-lived; and that feedback can also be effective, especially if given frequently. Related work suggests that whilst socio-demographic variables like income and household size effect energy use, psychological variables such as attitudes may be more important in determining *changes* in that use [6]. A variety of factors are thus important in understanding domestic energy use behaviours, including contextual, socio-demographic and psychological factors; factors that may also be significant in non-domestic settings.

Domestic and non-domestic settings vary however on a number of counts, creating very different contexts for behaviour change interventions [7]. The cost of energy use in the workplace is of little relevance to most employees, whilst the sharing of facilities and appliances may create barriers to behaviour change [8]. Some consider this to represent a 'tragedy of the commons' whereby management of a shared resource is delegated to a figure with only limited means of exercising control [9]. Employees can however be a captive audience and are subject to organisational policies [10], whilst the influence of social and group norms [8] and sense of community [4] may increase motivations to save energy in the workplace [11]. Common to all workplace settings is the relevance of group dynamics and interactions on energy saving [12], although variation in terms of size and sector also affect the potential for savings [3].

1.2. Pro-environmental behaviour & behaviour change

The field of pro-environmental behaviour has much to offer our understanding of energy use in the workplace. Pro-environmental behaviours are behaviours which intentionally seek to reduce the negative impacts of a person's activities on the natural and built world [13,14], such as reducing one's use of energy. Disciplines including psychology and sociology in particular have sought to understand what drives, limits and sustains pro-environmental behaviour and whilst the aim of this paper is not to deal directly with their theories and models, a very brief and inevitably limited introduction to them is given here as they set the context for most of the empirical investigations that are reviewed.

Based on assumptions of the 'information deficit' model, research in the 1970s suggested that knowledge of how to minimise environmental impacts will translate into pro-environmental behaviour [15]. This rationalist notion may in some instances be true, but often people do *not* act in accordance with their values or attitudes, leading to the so-called attitude-behaviour, or value-action, gap [16]. This gap has been attributed to differences between individuals, contextual influences, temporal discrepancies (i.e. that people's attitudes change over time), as well as the methodologies used in the measurement of attitudes versus behaviour [17]. Ajzen's [18] Theory of Planned Behaviour (TPB) has been particularly influential in research into this gap, suggesting that behaviours are driven by intentions which themselves are driven by a combination of attitudes, subjective norms, and perceived behavioural control [14]. Another highly influential model in pro-environmental behaviour is Stern's [13] Value-Belief-Norm (VBN) model which asserts that values relate to an individual's beliefs which in turn form intentions to act through norms. Others have linked pro-environmental behaviour to pro-social behaviour and create models focused on the importance of altruism and empathy [16].

Psychological understandings of pro-environmental behaviour have frequently been expanded to also include individual, social and institutional constraints. Blake [19] for example identifies three barriers to pro-environmental behaviour: individuality (barriers lying within the person), responsibility (barriers from personal feelings that they cannot influence the situation), and practicality (social and institutional constraints). Having reviewed many of the major psychological and sociological models of pro-environmental behaviour, Kollmuss and Agyeman [16] conclude that such behaviour represents a complex interplay between multiple factors: demographic factors, external factors (including institutional, economic, and social and cultural factors), and internal factors (including motivation, environmental knowledge, values, attitudes, environmental awareness, environmental involvement, locus of control, and responsibility and priorities). Their review highlights that most models fail to deal with the formation of habits and desires for comfort and convenience. An increasingly popular approach to researching energy use behaviours pays specific attention to such issues, focusing on everyday social practices and referring not to energy use but rather to 'practices-that-use-energy', such as cooking, showering, or using air conditioning [20–22]. Social practice theory pays attention to the social and collective organisation of practices, conceptualised as broad cultural entities which shape people's perceptions, their interpretations and the way they act [23]. Proponents of social practice theory suggest that this provides a more realistic perspective on behaviour change and that it highlights the problems faced in changing behaviours; problems which demand far more than the removal of contextual 'barriers' as they involve the organisation of everyday life [23].

1.3. In the workplace: pro-environmental behaviour & energy-use behaviour change

A review of studies in the workplace found that pro-environmental behaviours in this context depend on both individual determinants, e.g. attitudes and organisation-specific influences, e.g. management, however highlights that the interaction between individual and organisational factors is poorly understood [7]. It is suggested that intervening to promote pro-environmental behaviour in the workplace should focus not only on physical facilitation, but also tailored persuasive communication, and the active engagement of middle management [7]. A meta-analysis of studies to promote pro-environmental behaviours in the workplace finds that those most impactful interventions are those that involve cognitive dissonance (where differences between actions and pre-existing values or attitudes are highlighted), goal setting, social modelling (providing role models), and prompts (other types of treatment reviewed included 'making it easy' for employees, justifying the need for action, providing instructions, giving feedback, offering rewards, and seeking employee commitment) [24].

With regards to *energy* use behaviours in the workplace, past research has considered retail, industrial and manufacturing environments [25–27], as well as office-type environments, the latter of which is the context for this paper and will be the focus below. Psychological factors found to be important in energy saving are similar to that within pro-environmental behaviour more broadly and include moral norms, pro-environmental attitudes, personal responsibility, and antecedent beliefs [28–32]. This work additionally notes the importance of engaging employees through all stages of an energy-saving programme, including through participatory interventions which facilitate continual employee involvement [33,34]. The role of office management and organisational decision-making are also important in creating opportunities to reduce energy use [35–37]. Managers and the attitudes that they personally hold are central to creating opportunities to reduce energy use, and opportunities exist for human resource management to support the idea that managers are the gatekeepers to environmental performance. When it comes to tenanted buildings, building owners can play a role, with an ability to drive sustainability agendas through the requirements that they place on their tenants [38]. Increased technical monitoring, modelling and measurement of energy within the workplace may also aid energy saving [39–41]. Engaging building users with energy data can lead to new questions being asked about agency, responsibility and the relations between people and appliances and buildings that use energy, such that creative solutions may be found to reduce demand [42]. In relation to this, innovative ways of providing feedback on energy use, including in particular visualisation tools have indicated great potential in achieving energy savings [43,44]. The increasing complexity of both public and private sector workplaces as sites for energy efficiency interventions should not be overlooked, including with regards issues of privacy, trust, responsibility, control, organisational role, productivity, workloads, competing interests, staff relations, budgets, job losses and trade unions [45].

Academic literature which *directly assesses* the energy savings of behaviour change interventions in an office-type workplace is relatively sparse. Such literature reports on interventions initiated by, or on behalf of, organisations and ranges from the use of computer-based games [46] to comparative feedback [47] holistic programmes involving information, prompts, competitions, peer-education and discussion [48]. Some programmes combine these tactics with installing new technological features, such as energy efficient lighting and automated control systems [49]. Trials in the workplace have also been conducted by academic researchers, involving the provision of individualised feedback on desk-based

energy use [50] to the distribution of rewards, for example manipulating whether rewards provided are private or public, or monetary or social in nature [51]. This literature is reviewed in-depth in this paper.

Policy makers and practitioners are also interested in understanding energy use in the workplace and what can be done to reduce it. Bringing together numerous case-studies, a report into low carbon behaviours for the Scottish government found that the most successful behaviour change strategies, relating to energy in the workplace, employed technology and infrastructure upgrades [52]. Similarly, a report by the UK's Department of Energy & Climate Change [3] concludes that a combination of technology change, feedback to users, and norm activation tends to be the most successful strategy in delivering lasting changes in energy behaviours in the workplace. Such findings have relevance to policy makers working on energy issues worldwide.

Individually, these pieces of research and reports provide rich and important insights into various aspects of behaviour change interventions to save energy in specific workplace contexts. To date however there has been no systematic or comprehensive review to draw together these insights, or to speak more broadly about energy saving interventions in office-type workplaces. In this paper, we specifically consider offices in public and private buildings and include universities and schools. The scope of the paper is determined by the types of workplace reported upon in the studies we review and the methods employed to engage building users.[1] This paper addresses this gap and adds value to existing studies by identifying the interventions that consistently emerge as successful at saving energy in the workplace. It thus synthesises current knowledge, but also extends it, by identifying gaps which remain as challenges for future research.

This review brings together studies of employer-led behaviour change programmes as well as third sector and academic-led experiments and trials. These interventions are based on differing theoretical models and notions of behaviour change; however we do not judge the utility or validity of these, rather our assessment of intervention success is based directly on the energy savings generated i.e. the impact created. Whilst the paper is focused on interventions which aim to create changes in behaviour, changes in infrastructure and technology are frequently used in combination with these, thus we end up discussing both voluntary behaviour change and physical and contextual factors. In order to systematically analyse the interventions reviewed, we turn to the field of health-related behaviour change, which is arguably far more advanced than environment-related behaviour change. We adopt the Behaviour Change Wheel (BCW) as a framework [53,54] for characterising and evaluating the behaviour change interventions reviewed.

1.4. Behaviour change framework

Given the vast array of possible behaviour change interventions, it is important to develop an appropriate framework to assess the specific behaviour under consideration. A range of frameworks exist which characterise behaviour change interventions, however many of these are not comprehensive, taking the form of a checklist (e.g. MINDSPACE) [55] or taxonomy (e.g. EPOC's taxonomy of interventions to change health professional behaviour) [56] rather than being developed and grounded in theory; they are also frequently focused on just one domain (e.g. EPOC) [56]. One of the most rigorous and coherent frameworks to date has been the BCW.

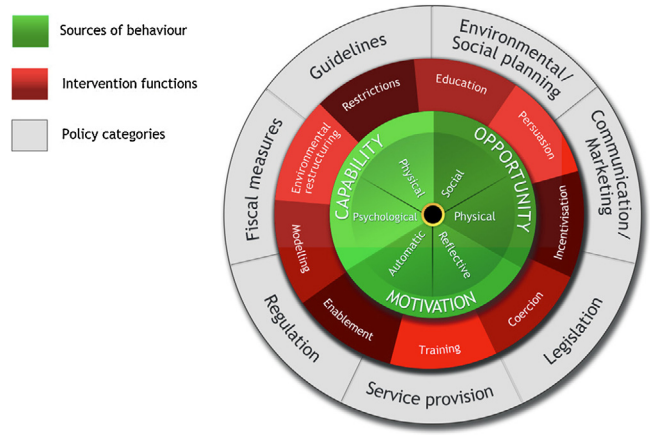

Fig. 1. The Behaviour Change Wheel (BCW). Reproduced from Michie et al. Implementation Science 2011 6:42 http://dx.doi.org/10.1186/1748-5908-6-42 under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/2.0).

The BCW was based on a systematic review of 19 previous frameworks of behaviour change interventions, particularly from health-related research (see Fig. 1). It is based on a theoretical model of behaviour that aims to cross cut commonly used models of behaviour (e.g. the Theory of Planned Behaviour) [18] and encompass the important roles of other key conceptual variables highlighted as important within behaviour change literature, e.g. impulsivity, emotional processing [57]. In this framework, the sources of behaviour are modelled into a 'COM-B system' (Capability, Opportunity, and Motivation leading to Behaviour) which theorises that an individual's Capability, Opportunity and Motivation (described as Sources of Behaviour) interact to generate Behaviour. Capability refers to an individual's psychological and physical capacity to engage in the behaviour concerned; Motivation refers to all those cognitive processes that energize and direct behaviour—not just goals and conscious decision-making but also automatic associations and priming; and Opportunity refers to all the factors that are external to the individual that make the behaviour possible. In addition, within Capability, Opportunity and Motivation, there are subdivisions which reflect important distinctions recorded within the literature. For example, Opportunity is subdivided into physical and social opportunities; physical Opportunity referring to environmental structures around us and social Opportunity referring to the culture that dictates the way we consider the behaviour (see the centre of the BCW in Fig. 1).

Around the central hub are nine 'Intervention Functions' that describe key features of behavioural interventions aimed at addressing deficits in one or more of the Sources of Behaviour (i.e. Capability, Opportunity or Motivation): Education, Persuasion, Incentivisation, Coercion, Training, Restriction, Environmental Restructuring, Modelling and Enablement; health-related examples of what these involve are given at the end of Table 1 . Multiple Intervention Functions are associated with each Source of Behaviour. These intervention functions have utility in identifying what kinds of behavioural intervention are possible and in classifying behavioural interventions that have already been conducted. A further layer of the BCW identifies seven categories of policy that could enable these interventions to occur. For a given behaviour in a given context, such as energy saving behaviour in a workplace, the BCW provides a structure to consider strategies that may be useful in promoting changes in behaviour.

[1] Energy savings reported in the studies reviewed differ according to; form of energy used (e.g. gas vs. electricity), source of energy use (e.g. computer screens, work stations, lights, whole office, whole building), length of time of intervention and over which the savings were sustained, sample size, experimental design (e.g. use of control or not) and building type (e.g. individual offices, open-plan floors, universities, schools).

2. Methodology

2.1. Systematic review procedures

We conducted a systematic review of empirical studies which assess interventions designed to change energy use behaviour in office-type workplaces; note that some focus on a range of pro-environmental behaviours, as well as the use of energy. A systematic review aims to collate all empirical evidence that fits eligibility criteria (set in advance) in order to answer a specific research question [58]. The key characteristics of a systematic review are: a clearly stated set of objectives with pre-defined eligibility criteria for studies; an explicit, reproducible methodology; a systematic search that attempts to identify all studies that would meet the eligibility criteria; an assessment of the validity of the findings of the included studies, for example through the assessment of risk of bias; and a systematic presentation, and synthesis, of the characteristics and findings of the included studies [58]. We pay attention to each of these characteristics as set out below.

2.1.1. Eligibility criteria

To be included in the review, papers needed to be a study of a behaviour change intervention in relation to energy use in the workplace and to report on the energy savings generated through

Table 1
Intervention Functions adopted in each of the reviewed studies, ranked according to energy savings generated; some studies differentiate energy savings from different combinations of interventions and these are given as separate entries in the table. It should be noted that energy savings reported differ according to; form of energy used (e.g. gas vs. electricity), source of energy use (e.g. computer screens, work stations, lights, whole office, whole building), length of time of intervention and over which the savings were sustained, sample size, experimental design (e.g. use of control or not) and building type (e.g. individual offices, open-plan floors, universities, schools). Definition of Interventions Functions given below (Michie et al., 2014, p.111 [53]) [10,23,46–51,60–63,67–71,75–80,82].

	Energy savings generated	Education	Persuasion	Incentivisation	Coercion	Training	Restrictions	Environmental restructuring*	* Signs, posters, physical material	* Device, displays , screens	* Retrofit	* Automation	Modelling	Enablement
Shelley et al. 2011, 2012 (study 12)	50% [electricity]	■	■					■	▒	▒	▒	▒	■	■
Yun et al. 2015 (study 21)	38% [electricity; *with automated control*]	■	■					■		▒		▒	■	■
Craig & Allen 2015 (study 18)	31% [electricity]	■						■	▒				■	■
Yun 2014 (study 13)	30% [electricity]	■						■		▒		▒	■	■
Yun et al. 2015 (study 21)	25% [electricity; *with manual controls*]	■	■					■		▒			■	■
Jaramillo Garcia et al. 2015 (study 22)	21% [electricity]							■				▒		
Metzger et al. 2011 (study 10)	20% [*automated control system*]							■				▒		
Kamilaris et al. 2015 (study 19)	20% [computer electricity]	■		■				■	▒				■	
Orland et al. 2014 (study 15)	13% [electricity]	■	■	■				■	▒	▒			■	
Yun et al. 2015 (study 21)	13% [electricity; *feedback only*]	■	■					■		▒				
Owen et al. 2010 (study 6)	12% [electricity]	■	■	■				■	▒	▒	▒	▒	■	■
DECC 2012 (study 9)	10% [gas]	■	■	■									■	■
Gustafson et al. 2008 (study 2)	9% [electricity]	■	■	■				■	▒				■	■
Carrico et al. 2011 (study 1)	7% [*feedback*]	■	■											
Dixon et al. 2015 (study 17)	6.5% [*comparative feedback*]	■	■					■	▒	▒			■	
Handgraaf et al. 2013 (study 3)	6.4% [*public, social rewards*]	■	■	■				■		▒			■	
Metzger et al. 2011 (study 10)	6% [*competition*]			■				■		▒			■	
Staats et al. 2000 (study 7)	6% [gas]	■	■					■	▒					
Nye et al 2009; Hargreaves 2011 (study 11)	5.4% [electricity]	■	■					■	▒	▒			■	
Carrico et al. 2011 (study 1)	4% [electricity; *peer education*]	■	■											

Table 1 (*Continued*)

Murtagh et al. 2013 (study 5)	Reduction found [electricity]	■	■					■		■			■	
Nilsson et al. 2015 (study 20)	Decrease in use but not significant [electricity]	■	■	■									■	
Metzger et al. 2011 (study 10)	Negligible impact [electricity; *letters*]	■												
Handgraaf et al. 2013 (study 3)	*Increased* energy use [electricity; *private monetary rewards*]	■	■	■				■		■				
BELOW NOT IN RANKED ORDER AS NO % ENERGY SAVING IS REPORTED (different units may be used instead)														
Kuntz et al. 2012 (study 4)	Savings of 463 megawatt hours	■		■				■	■				■	
Werner et al. 2011 (study 8)	Lights left on in classrooms reduced from 51% to 17% [*presentation*]	■	■					■	■					
Tolias et al. 2015 (study 16)	5.6% reduction in idle time, but not statistically significant	■		■				■		■			■	
Werner et al. 2011 (study 8)	Little or no impact [*signs with no presentations*]	■	■					■	■					
Aga-Hossein et al. 2015 (study 14)	Temporary increase in stair usage but not statistically significant	■	■					■	■					

Definitions of Intervention Functions (examples based on health-promoting activities):

- **Education** Increasing knowledge or understanding e.g. providing information to promote healthy eating.
- **Persuasion** Using communication to induce positive or negative feelings or stimulate action e.g. using imagery to motivate increases in physical activity.
- **Incentivisation** Creating expectation of reward e.g. using prize draws to induce attempts to stop smoking.
- **Coercion** Creating expectation of punishment or cost e.g. raising the financial cost to reduce excessive alcohol consumption.
- **Training** Imparting skills e.g. advanced driver training to increase safe driving.
- **Restriction** Using rules to reduce the opportunity to engage in the target behaviour (or to increase the target behaviour by reducing the opportunity to engage in competing behaviours) e.g. prohibiting sales of solvents to people under 18 to reduce use for intoxication.
- **Environmental restructuring** Changing the physical or social context e.g. providing on-screen prompts for GPs to ask about smoking behaviour.
- **Modelling** Providing an example for people to aspire to or imitate e.g. using TV drama scenes involving safe-sex practices to increase condom use.
- **Enablement** Increasing means/reducing barriers to increase capability or opportunity e.g. behavioural support for smoking cessation, medication for cognitive deficits, surgery to reduce obesity, prostheses to promote physical activity.

the intervention (we use the term 'workplace' to refer to an organisational context where employees work alongside each other in an office-type environment; we include offices in private and public building, universities and schools); a study published in or since the year 2000[2]; a study published in English. Studies could be of interventions in any country and could be published either in peer-reviewed academic journals or in grey literature (i.e. reports from organisations, governments or the third sector).

2.1.2. Systematic search methodology

Searches for eligible studies were run on multiple academic online search engines: Scopus, Web of Science (databases: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH), ABI-INFORM, ASSIA, PsychINFO and Ergonomics Abstract. The ECEEE and ACEEE Summer Study Conferences online archives were searched by hand. Grey literature was searched by looking at individual company reports from government and non-governmental agencies e.g. DECC, DEFRA, the Carbon Trust and GAP (Global Action Plan), and by using online databases including the Energy Citations Database (DOE), Open EU, and UKOP (UK's open Publication Platform).

In order to capture the quite dispersed range of literature in this field, queries used in the search strategy were chosen to cover four main areas; energy-related, workplace, pro-environmental/energy behaviour change, and energy systems. Appendix A provides results on the number of papers and reports identified under different combinations of search terms. In total, 24 papers reporting on 22 separate interventions were identified which fit the eligibility criteria for inclusion in our review.

[2] Final review conducted January 2016.

2.1.3. Assessment of validity

Systematic reviews often include an assessment of the validity of the findings of the studies included [58], and this is sometimes, but not always, a selection criteria [59]. Given the limited number of papers in existence in this area, we did not set any selection criteria in relation to validity or quality, however we do reflect on these issues for the selected studies overall (see Section 3.3).

2.1.4. Systematic presentation

With regards to the systematic presentation and synthesis of findings from the included studies, we use the BCW to characterise and evaluate behaviour change interventions, as outlined above (see Section 1.4).

2.2. Overview of the reviewed interventions

Of the 22 interventions identified for review and analysis, 2 were from grey literature. Fifteen of the reviewed interventions reported on the results of focused trials or experiments (which often used control groups) conducted by the authors themselves, whilst seven reported on holistic behaviour change programmes initiated in conjunction with employers (see Appendix B for summary details of each study).

In terms of the interventions reported by the reviewed papers, a variety of workplace settings were examined: 9 were run in commercial companies, 8 in universities, 3 in government buildings and 2 in a school. These workplaces were located in the USA (n = 10), UK (n = 5), the Netherlands (n = 3), Canada (n = 2), Sweden (n = 1) and Singapore (n = 1); and differed markedly in size ranging from 22 employees (for individual desk plug-load trials), to 2112 employees (for self-report questionnaires), to energy use behaviour

change programmes targeting thousands of employees. Interventions lasted from 2 weeks to 7 years.

Seven of the interventions explored electricity use in general whilst others concentrated more specifically on electricity use in an individual office (n = 1), at the desk (n = 6) or from computers only (n = 3); or electricity for lighting (n = 3), for heating and cooling (n = 2), and for lift usage (n = 1). Most of the papers (n = 18) reported changes in energy consumption (electricity or gas) during the course of the intervention, with 4 papers reporting on observing energy-using appliances and equipment, or artefacts of energy use (e.g. the extent to which lights are turned on or off, the coverage of heaters, the use of stairs vs. lifts, the time computers are spent 'idle'). Half of the papers (n = 11) also utilised quantitative questionnaires to survey participants pre- and post-intervention to gather self-reported changes in behaviour due to the intervention, whilst 5 used qualitative methods (interviews, focus groups, participant observation) to understand participant's experiences during the interventions. The remaining papers relied on physical measures of energy use only and did not engage directly with participants. Where positive energy savings are reported in terms of measured reductions in energy consumption (rather than observed changes in energy-using appliances or artefacts of energy use), savings range from 5.4% to 50%.

3. Intervening in energy use behaviours in the workplace: a synthesis of available evidence to date

The 22 studies reviewed in this paper were analysed using the BCW framework. These studies were numbered 1–22 for ease of reference, and these numbers are used to identify the studies below and in tables and figures. We categorised the methods used in the interventions according to the nine Intervention Functions of the BCW. This allowed us to examine whether any of the Intervention Functions were particularly associated with successful energy savings (see Section 3.1), which of the related Sources of Behaviour (i.e. Capability, Opportunity and Motivation) were involved (see Section 3.2), and which had not been previously utilised in this context.

3.1. The success of different forms of intervention

Table 1 shows how the methods employed in the interventions reviewed correspond to the nine categories of Intervention Functions of the BCW (for full details see Appendix C). Some methods fall into multiple categories i.e. constitute more than one Intervention Function. Below we work through each Intervention Function in turn, discussing the methods which relate to each category and the energy savings they generate.

3.1.1. Education

Education in the BCW is described as 'increasing people's knowledge or understanding', an example from the health domain being the provision of information to promote healthy eating [53,p.111]. All but 1 of the 22 reviewed interventions included methods which constitute Education, including the provision of feedback (regular or one-off), instructions, reminders, checklists, and tips. This information concerned generic energy-saving actions, individualised feedback on plug-load energy use, and whole building energy audit results and was provided through a range of media including printed material (brochures, newsletters, posters, signs) and email, or through verbal communication (direct to employees or through peer-education). One study, in a school setting, also involved Education through assemblies and lessons which focused on energy efficiency [60] (study 18).

We highlight that there is some overlap between the categories Education and Environmental Restructuring, the latter of which involves the changing of context – either physical or social – such as the providing of on-screen prompts for GPs in the health domain [53]. Providing energy-saving prompts by email directly to employees or placing signs by light switches asking employees to turn them off, could be argued to be both educating users as to energy saving actions that can be taken, and to be providing contextual cues to remind people of behaviours that they should already be undertaking (see Section 3.1.7). Following Michie et al. [53], we therefore consider reminders, prompts and checklists to also be environmental cues and thus constitute Environmental Restructuring. Depending on the language or imagery used, these methods may also constitute Persuasion (see Section 3.1.2).

Given its ubiquity, it is hard to differentiate the energy saving potential of Education from that of other Intervention Functions which are used in conjunction with it. For example study 18 [60] took place in a school and reports on extensive use of Education through assemblies, lessons and assignments focusing on energy-saving measures, as well as through the use of signs and posters in the school and student homes, and through information sent to parents and local officials through newsletters. The intervention overall achieved impressive energy savings of 31% but given it also included a prominent Modelling element (Section 3.1.8) through a strong energy champion (the District energy Manager) it is hard to apportion reasons for the savings generated.

Four of the interventions reviewed specifically focused on the utility of different types of education however. Carrico and Riemer [10] (study 1) compared the impact on energy consumption of generic energy advice given through postcards sent directly to individuals, with the impacts of combining this energy advice alongside either emailed feedback on energy use at the building level, or of peer education involving employees acting as points of contact and information for colleagues. Feedback and peer-education generated energy savings of 7% and 4% respectively whilst the provision of information alone led to an *increase* in energy use of 4%. Kamilaris et al. [61] (study 19) found that participants considered emails a better means of communicating information than either posters or leaflets, with specific rather than general advice to be most meaningful. The study draws attention to the frequency and duration over which feedback information is provided, suggesting emails sent weekly would be effective in providing information but would not annoy employees (as they might do if sent more frequently). The study reports sustained energy saving behaviour over a 3 month period post-intervention, indicating the potential for savings over a longer-term. Direct information provision (through signs and stickers) and peer education were also compared by Werner et al. [62] (study 8), finding that whilst the former generated little or no impact, the latter generated a reduction in the percentage of classrooms with lights left on after class from 51% to 17%. Peer-education provided the opportunity for students to raise questions and concerns and for these to be addressed, thus removing barriers to energy saving behaviour; some students had, for example, expressed a belief that they were not allowed to turn off the lights when leaving the classroom as it was a 'public space', a fear which was allayed through the peer-education. The third study focusing on the provision of information utilised an interactive poster to persuade employees to use the stairs rather than a lift in their 5 storey building, and thus to save energy [63] (study 14). The poster was designed to be persuasive (thus the intervention represents Persuasion too, Section 3.1.2) through images of a tree with leaves growing on it in relation to stair usage. Whilst employee pro-environmental attitudes increased over the course of the trial and their use of stairs increased rapidly for a day or two after the poster was installed, there was no statistically significant change in behaviour over the following 2–4 weeks of the study.

Based on the available evidence, it would appear that targeted information and knowledge passed on by peers is likely to be more effective than general information provided through printed mate-

rials such as stickers and posters. This is in line with the critique of 'information-deficit' models which propose that it is not productive to consider behaviour change simply as requiring a correction in understanding through provision of information [64]. Indeed users can be considered to have their own expertise and contextualised understanding that can usefully input into developing new policies, support structures and interventions to achieve change [65,66]. However this is not to say that the provision of information is not sometimes useful and perhaps necessary, particularly when new products and systems are being implemented. Important considerations include that information is contextualised and easy to understand, and that information is from a trusted source with sufficient expertise (this can include professionals but also peers) [66].

3.1.2. Persuasion

Persuasion is defined in the BCW as 'using communication to induce positive or negative feelings or stimulate action', for example, the use of imagery to motivate increases in physical activity in the health domain [53,p.111]. Fourteen of the 22 reviewed interventions reported on methods which constitute Persuasion. Methods fall into this category in a number of ways: first, many methods constitute direct persuasion by focusing on the provision of information through the use of graphs, tables, encouraging text, images and interactive displays on either printed or electronic material i.e. visual imagery to induce positive feelings and stimulate action, for example signs and images to make building users feel personally responsible. Some other methods use persuasive verbal communication, such as through peer-education discussed above under 'Education' (see Section 3.1.1). Some further methods are harder to categorise, such as the school motto which was used as a vehicle to promote sustainability, and the articulation of an 'ethic of sustainability' [67,69] (study 12a and 12b) and 'ethos of commitment and can-do attitude' [48] (study 2). These communication tools are aimed at inducing a social environment that will stimulate action, thus constitute Persuasion.

The school motto and ethic of sustainability referred to above [67,68] (study 12a and 12b) were employed as part of an wide-ranging energy saving programme, encompassing building renovation and new technologies, along with changes in governance and culture, that generated by far the greatest energy savings of any of the reviewed papers, of 50% over 7 years. As such it is not possible to distinguish the individual impact of the school motto or ethic of sustainability; rather in this case the programme's success was put down to its combination of methods and holistic approach. Similarly, the example of the ethos of commitment and can-do attitude arises from a wider programme, successful in reducing electricity consumption by 9% [48] (study 2).

Again, there is clearly some overlap between Intervention Functions. Behaviour change initiatives, particularly in the field of pro-environmental behaviour by their very nature have a specific agenda of behaviour change and of persuasion. Often therefore when information is presented, it is also presented in a persuasive style or context; Education interventions therefore frequently overlap with Persuasion interventions. Not all Persuasion will constitute Education however, as for example the motto, ethic and ethos articulated in the examples provided above aim not to educate i.e. increase knowledge, but explicitly to persuade i.e. induce positive feelings towards the desired behaviour. It should be noted that all Persuasion reported in the reviewed papers focuses on promoting positive feelings rather than negative ones. The discussion on Coercion (see Section 3.1.4) and Restriction (see Section 3.1.6) may help to understand why this is so.

Persuasion has the potential to change behaviour, particularly if done by peers and if communicating a deeper message (e.g. ethos of sustainability) rather than superficial information (e.g. to turn off a light). It is also noted that in this context, information that it is tailored to and meaningful to the recipient is usually more persuasive, and thus more likely to be acted upon [66].

3.1.3. Incentivisation

Incentivisation in the BCW is described as 'creating the expectation of reward', for example through the use of prize draws to induce attempts to stop smoking in the health domain [53,p.111]. Twelve reviewed interventions reported on methods which constitute Incentivisation, based on two different approaches. Incentivisation could involve the provision of rewards in the form of cash, bonuses, food, and other prizes. However rewards may also be social in nature i.e. not based on financial or other gains, but rather a sense of achievement, for example the provision of positive descriptive comments in employee reviews. Social rewards tend to be given in relation to meeting pre-established targets or goals around performance of energy-saving actions, although goal-setting (with no expectation of reward) is itself also a form of Incentivisation. Rewards may be given to employees on an individual basis or based on groups of employees working together. Three studies involved Incentivisation in the specific form of on-line games. These encouraged competition between (groups of) employees and incentivised them to win by behaving in the most energy-saving way.

Incentivisation methods reported by 3 of the reviewed interventions were used as part of a holistic behaviour change programme i.e. alongside multiple other methods, thus it is difficult to determine their contribution towards energy savings. One study notably relies heavily on Incentivisation [48] (study 2) employing 5 separate methods simultaneously as part of a holistic behaviour change programme (most papers report only 1 or 2) and generates energy savings of 9%.

Other studies investigating the impact of Incentivisation were part of academic-led trials. Handgraaf et al. [51] (study 3) reports that publically given rewards outperformed ones given privately, and that social rewards (grade points with a descriptive comment) outperformed monetary ones (up to €5); in fact public social rewards generated energy savings of 6.4% whilst private monetary rewards led to an *increase* in energy use. One study encouraged competition between employees, although with no tangible rewards beyond social recognition [69] (study 10). It involved employees accessing, through an online digital dashboard, the electricity use and carbon dioxide equivalents of their 'pod' i.e. clusters of six to eight employees, displayed alongside the same data for all other pods. Over a period of 4 weeks, the experiment generated energy savings of 6%.

Three studies focused on the use of on-line games, one of which, called 'iChoose', engaged groups of employees in competition with each other [46] (study 4). Although organised through their work, this intervention crossed the domestic/non-domestic divide, as employees were encouraged to record energy saving activities in their *own homes*, and in doing so gained points for themselves and their team *at work* (made up of colleagues they worked most closely with). There were small monthly cash prizes for individuals in the lead and team prizes at the end of the game. Estimated savings of 463 megawatt hours of electricity were made, although notably energy saving activities subsided once the game had finished. Drawing on ideas of 'serious games', another study developed and trialled an on-line game called 'Energy Chickens' in which the health of a pet chicken related to plug-load energy use of the employee [70] (study 15). As a result of the game, average energy use reduced by 13% (23% over weekends, and 7% on work days i.e. Monday-Friday) and 69% of employees said the game helped increase their energy awareness, including outside of work. This study ranked 4th highest in energy savings amongst those reviewed in this paper, but it should be noted that despite the large reductions in energy use during the game, these savings did *not* persist

and energy use returned to baseline levels. Speculating on reasons for the lack of persistence of energy savings, the authors relay how the office IT support stopped people turning off their computers at night and at weekends (as incentivised in the game) so as not to interfere with on-line security and back-up management, highlighting clashes between the policies and goals being presented to employees in that context. Another study employed a pervasive game called 'IdleWars' to provide feedback on the time a computer was 'idle' i.e. had no mouse movements or key strokes for more than 5 min, and to encourage employees to catch or 'bust' each other when this happened [71] (study 16). Whilst there was no statistically significant change in energy use as a result of the game, the time that computers were left idle reduced by 5.6% over the 2 week trial. Whilst the game worked well to engage participants and stimulate discussion around energy use, it inadvertently produced some anti-energy conservation behaviours by being appropriated by employees for fun (e.g. moving a colleague' mouse whilst they were away from the desk to create another 5 min idle period, which could then be 'busted'). Issues of privacy and productivity were also highlighted by the study, as the game involved touching others' computers and potentially disruption to work routines.

It appears therefore that incentives can be effective but must be chosen with care as they do not always work; whilst based on limited evidence, indications are that incentives that are made publically and that are social in nature may be most effective. Gaming can also be used to incentivise particular behaviours, but care must be taken in how they might be appropriated and potential impacts on productivity and privacy. As has been found in other research however, impacts of incentives may be short-lived and subside when incentivisation finishes [72]. Interestingly, *none* of the seven highest performing interventions studied employed Incentivisation.

Methods which involve Incentivisation are often based on groups of employees working together and invoke a sense of competition and comparison, for example competitions between groups of employees on different floors of an office building (e.g. through public display of energy savings generated by each floor) or comparison with individual colleagues. An interesting relationship therefore exists between Incentivisation and Modelling (see Section 3.1.8).

3.1.4. Coercion

In the BCW, Coercion is described as 'creating expectation of punishment or cost', for example raising the cost of alcohol to reduce excessive alcohol consumption in the health domain [53,p.111]. No reviewed interventions used methods which fall into this category, although two referred explicitly to a desire *not* to use negative reinforcement in terms of punishment or restriction. The inattention to forms of coercion in behaviour change interventions in the workplace represents a gap in the research, one which also appears to be present in relation to domestic energy use and to other sorts of pro-environmental behaviour. This gap may be explained by researchers wishing to avoid the 'negative connotations' associated with the punishment or costs inherent to Coercion, or because they fear it may threaten to disrupt the relationship between positive employee attitudes and productivity at work [73]. It may also be that it is difficult to put Coercion into practice; practically it may be difficult to penalise employees for wasting energy in the workplace and contextual considerations are important here. A pay related penalty might be the most obvious penalty.

3.1.5. Training

Training in the BCW refers to the 'imparting of skills', for example advanced driver training to increase safe driving in the health domain [53,p.111]. Whilst most studies included an element of imparting knowledge and understanding (i.e. Education) none went as far as aiming to impart skills (i.e. Training). It should be noted that in the studies reporting on the installation of an energy use feedback device at for example the desk level, there may well have been an element of training in its use; however if this was involved it is not detailed in any of the papers reviewed.

Interventions tend to focus on either the use of electricity for lighting, computing and other electrical equipment, and/or energy usage for heating or cooling of office spaces. The absence of training in these interventions may reflect, at least in part, the prevailing trend of centralising energy management in the workplace, which limits direct employee control of functions such as lighting and local space heating and delegates them to a Facilities Manager [9]. Accordingly, the inattention to forms of training in behaviour change interventions may exist simply because it is difficult to envisage what training might actually involve. Training may be more relevant in more traditional offices with decentralised energy functions where, for example, employees can operate air conditioning interfaces, but often without any knowledge in how to best use them, such as closing windows whilst the air conditioning is active. Training may also become more relevant alongside the introduction of new smart energy technologies or systems [8], which return some influence over local conditions to building occupants in order to improve satisfaction levels, which are often low under the centralisation strategy [74].

3.1.6. Restriction

In the BCW Restriction is described as 'using rules to increase the target behaviour by reducing the opportunity to engage in competing behaviours', for example by prohibiting sales of solvents to people under 18 to reduce abuse of these, in the health domain [53,p.111]. No reviewed interventions used methods which fall into this category, though in one study [23] (study 11a) they appeared to inadvertently create a similar effect. This intervention included the use of 'Environmental Champions' (employees who would act as a point of contact and information for colleagues), and found that colleagues were at times unhappy with the idea that these volunteers may be 'spying' on their activities, referring to them as the 'environment-police'; in fact the Champions themselves discussed sometimes feeling uncomfortable in this role. The intervention led to a reduction in energy use however, generating 5.4% saving in electricity. Based on extensive participant observation, the paper argues that this was little to do with changing employee's attitudes toward, knowledge about, or values regarding the environment, but rather to do with working with the existing 'officially accredited' rules for office conduct through the introduction and policing of new social expectations and rules involving a pro-environmentalism.

Again, the inattention currently paid to forms of restriction constitutes a gap in the research. It may again be that this gap is, in part, explained by difficulties in envisaging exactly what restriction in relation to energy use in the workplace may involve. Informal rules often exist with regards to turning off specific individual equipment after use, and may be introduced alongside environmental restructurings (see below) such as providing recycling bins. Policing here tends to be informal through social approval. Formal rules are harder to envisage and to enforce, as was discussed regarding Coercion and the potential threat of punishment. It may be that there are interesting contrasts with the use of Enablement, which may be considered the reverse of Restriction. Further empirical investigations in the area would be useful.

3.1.7. Environmental restructuring

Environmental Restructuring is referred to in the BCW as the process of 'changing the physical or social context' in order to promote a particular behaviour, for example providing on-screen

prompts for GPs to ask about smoking behaviour in the health domain [53,p.111]. Nineteen studies reviewed here (i.e. almost all of them) reported methods which constitute physical Environmental Restructuring, although there are interesting differences amongst these. Four different forms of Environmental Restructuring appear within the interventions reviewed: signs and posters (i.e. physical material), electronic feedback devices and 'dashboards', retrofit technology, and technology automation.

Regarding changes to the physical context, 11 of the interventions report on the use of signs, stickers or posters, for example by light switches to provide cues and prompts for employees to turn off the light when not needed. Six of the reviewed interventions report on the use of electronic devices and online dashboards to provide real-time energy use feedback (which may implicitly promote awareness and therefore considered use of energy), two use computer screens in gaming interventions, whilst seven use email prompts and checklists. Other alterations to physical context focus on technical efficiency; two interventions reviewed here included the use of retrofitting to increase the energy efficiency of office equipment such as lighting or heating whilst six interventions included the use of automation to reduce energy demand, for example by turning off electronic equipment when not used for over a certain time, or the automatic control of lights. As noted in Section 3.1.5, these forms of Environmental Restructuring that focus on using technology to improve efficiency arguably reduce the need for employees to alter their behaviour, though there are potential costs to employee satisfaction.

In terms of the energy saving potential of physical Environmental Restructuring, the use of signs or visual imagery has been discussed above (see Sections 3.1.3 and 3.1.2), suggesting the provision of information alone creates little impact. The use of feedback devices, in the form of software tools or physical displays, may offer more potential. Murtagh et al. [50] (study 5) report a study involving installation of the 'MyEcoFootprint' gadget to provide employees with real-time feedback on desk-based energy use. This led to savings in energy (not quantified in the paper) although they diminished over time. A study reporting on a piece of pilot research found energy savings of 30% generated by an energy dashboard which provided feedback to employees, as well as the ability to control devices remotely and to set automated on/off timing controls [75] (study 13). The full study [76] (study 21) which developed from this pilot reports even higher savings through this combination of online remote (manual) controls (to turn off devices) and automated controls (to schedule turning on and off), with savings of 38% in desk-based electricity use (laptops, monitors, phones, desk light) during the intervention compared to the pre-intervention baseline.

A further study by Owen et al. [49] (study 6) also examined real time feedback, provided through a dashboard and in relation to energy use for lighting. Their trial compared the effect of retrofitted lighting with automatic daylight dimming, to the effect of lighting controlled individually by employees, and a control group with no intervention on lighting (i.e. neither automation nor employee control). Employees working under all of these conditions could access the real time feedback provided through the dashboard, but those working with no lighting measures made energy savings of only 2.4%, whilst those with individual switches saved 12.0% and automated lighting saved 12.6%; increasing individual control of lighting and automating lighting controls thus had a similar impact on energy savings. Another study [77] (study 22) developed an 'adaptive proximity controller' to detect employee activities at their desks and in response to turn computer screens on or off. Controlling computer screens in this way generated energy savings of 21% compared to the pre-intervention baseline.

Other studies which have used automation as part of their intervention strategy have also tended to be successful. Metzger et al. [69] (study 10) describe how the use of automated controls to switch off non-essential circuits when a 'pod' (i.e. desk area) was empty for 15 min generated energy savings of 20%. The highest performing intervention amongst all studies reviewed, generating 50% savings in energy [67] (study 12a), was a holistic behaviour change programme and also included automation to allow shut-off of computer labs, and retrofitting with energy efficient light bulbs. The exact contribution of these methods to the overall energy savings is however not known.

It should be noted that five of the top seven performing interventions involved automation of technology. Whilst they may appear separate from behaviour change interventions, technological solutions to workplace energy saving operate both *on* and *in* the same physical and social context and so are inextricably part of the story. Whilst responsibility for saving energy is in many ways transferred to the new technologies, these necessitate some form of response from employees, either in the form of passive acceptance or more active engagement. For example with respect to automated heating and lighting systems, occupants may simply over-ride or subvert the system if they find they do not align with their personal notions of comfort. They might for example cover sensors or air vents, or acquire a personal desk lamp or heater. Simultaneously, the investment in new technology may have longer-term impacts on the behavioural norms of employees by signalling an organisational commitment to pro-environmental goals.

3.1.8. Modelling

In the BCW, Modelling is described as 'providing an example for people to aspire to or imitate', for example the use of television series involving safe-sex practices to increase condom use in the health domain [53,p.111]. In total, 17 of the reviewed interventions report on Modelling, but in a number of different ways. Firstly, three interventions report on methods which employ modelling in a very explicit format, through the profiling of particular employees who exemplify good energy conservation behaviour, either individually or through peer-education of others. These employees received public recognition for their actions, through official roles and titles, or through recognition programmes that included the giving of prizes. All of these modelling interventions are introduced as part of holistic behaviour change programmes, which produced relatively high energy savings: 12% [49] (study 6), 9% [48] (study 2), and 5.4% [23,78] (study 11a and 11b).

Secondly, 12 studies reported on interventions that involved the comparison or competition between colleagues, either individually or in groups (from small 'pods' of 6–8 employees up to competitions between whole floors within a building) or gaming amongst them. Comparison may be encouraged through bringing colleagues together to share stories, through 'opportunities for bragging', or through public display of the energy savings of other colleagues, groups of colleagues, or an office average. Such interventions also often constitute Incentivisation, as discussed above (see Section 3.1.3). These interventions tended to occur in conjunction with multiple other interventions, thus the energy saving potential of modelling through comparison and competition is hard to assess. One study focused specifically on comparative feedback amongst employees of a US University, with comparison between the 6 separate buildings involved [47] (study 17). The year-long energy saving campaign; which involved an online platform of information, a website, email reminders and posters, generated average energy savings per building of 6.5%. Pro-environmental attitudes and behavioural intentions amongst participating employees were *not* found to alter as a result of the campaign, indicating that the energy savings were generated by employee's motivations to outperform their colleagues in other buildings. The study's authors note however that the energy savings were not sustained after the end of the campaign, although the following year they were

higher than in control buildings which also formed part of the study. The authors suggest therefore that campaign designers commit to long-term programmes in order to sustain energy savings. Another study which explored the role of comparison amongst colleagues reports that employees found this to be the *least* useful tactic of those employed, which also included the provision of advice, information and team-level energy-use statistics [61] (study 19). The study suggests that comparisons on an individual basis may have raised issues of privacy amongst employees, as participants suggested that comparisons between groups of colleagues (in different offices or departments) might have been more useful. The scale at which comparison with, or modelling of, colleagues is made is clearly important. A further study appealed directly to existing group identity amongst employees as part of an intervention consisting of goal-setting, prompts and feedback [79] (study 20). Feedback incorporated group identity through encouraging messages which appealed to the positive traits of the group (as identified by group members prior to the intervention). No conclusive results could be drawn from the study in terms of energy savings, but it was found that the intervention changed behaviours and increased feelings of group identity during the experimental period.

And thirdly, one study reports the widespread recognition of particular teachers, students and the Principal of a school, as playing instrumental roles in achieving energy reductions and providing examples for others to follow [68] (study 12b). In this sense, these individuals may be seen as acting as models for others; however this occurred organically as a consequence of the initiative, rather than being its explicit aim. This unintentional modelling was part of the highly successful holistic programme which generated energy savings of 50%. The other study which reports on interventions within a school also employed Modelling in a similar sense, through the District Energy Manager, described as a strong champion for energy efficiency [60] (study 18).

It should be noted that all of these examples of Modelling involve colleagues of employees within the same organisation, rather than external individuals, e.g. celebrities, as in the health-related example given above. It is hard to draw concrete conclusions about the individual contribution of Modelling to energy savings given its ubiquity (for example as forms of competition and comparison amongst employees) or its presence in holistic programmes alongside multiple other methods, however considering the social environment of most workplaces, it is clearly of interest to those involved in behaviour change interventions in these environments.

3.1.9. Enablement

Enablement in the BCW is defined as 'increasing means/reducing barriers to increase capability or opportunity',[3] with the note that the increase in Capability is specifically beyond what can be achieved with Education and Training, and that the increase in Opportunity is beyond what can be achieved with Environmental Restructuring [53,p.111]. Examples of Enablement in the health domain include behavioural support given for smoking cessation and surgery to reduce obesity. Seven of the reviewed interventions report on methods which constitute Enablement, although in very diverse ways and often as part of holistic behaviour change programmes, again making it difficult to determine their individual utility.

Two studies report on Enablement through the use of an energy dashboard which enables employees to remotely and automatically control electronic devices at their desks, generating 30–38% energy savings [75,60] (studies 13 and 18). Two studies report on Enablement through individualised help and assistance (by a nominated employee) in thinking through the energy use of employees' desks or workspaces and ways in which this can be reduced; generating fairly high energy savings of 9% [48] (study 2) and 12% [49] (study 6). One study reports Enablement in the form of altering after-hours working practices by enabling (and incentivising) employees' moves to one particular location in the building, so as to reduce energy consumption in other parts [80] (study 9), again achieving fairly high savings of 10%. One other intervention reports on Enablement as school students are given control to adjust thermostats [60] (study 18), whilst another reports on four separate methods; providing custodians (i.e. caretakers) and students the opportunity to participate in school governance (including over energy use), providing custodians the ability to alter practices (e.g. when lights are turned on and off at the start and end of the day), allowing students control of spending money saved through energy reductions (which was used to purchase wind energy), and by offering courses in sustainability which the school viewed as important in promoting a wider knowledge of and ethics for sustainability, including around issues of energy [68] (study 12b). This study was the highest performing study reviewed, generating energy savings of 50%.

It should be noted that what sets 7 of the 12 highest performing studies apart from the lower performing studies is their use of Enablement. As Enablement was used alongside other forms of intervention it is difficult to attribute success solely to it however its presence within the higher performing and noted absence within the lower performing interventions clearly suggests it may be linked to successful energy savings. Enablement seems to be related to a change in levels of employee control and responsibility, for example responsibility for ones' desk plug load, or control over when lights are routinely turned on and off, or over organisational governance and budgets. We suggest that potential forms of enablement be researched further to understand its utility more clearly and identify the most successful forms of its implementation in this field.

3.1.10. Summary of intervention success

Our review also allows us to draw some conclusions about what makes an effective intervention into energy use behaviours in the workplace. We highlight that our conclusions are tentative given the relatively small number of papers reviewed and that many studies use multiple forms of intervention in combination meaning that attributing effects to any one function is impossible. Nonetheless, our review provides important descriptive data highlighting intervention functions that have most frequently been associated with success. In particular, interventions characterised as involving Enablement, forms of Environmental Restructuring, and those including aspects of social influence, including Modelling, appear to be particularly successful.

Enablement in particular appears to be a successful intervention function and has been discussed as increasing the means or reducing the barriers to increase a person's Capability or Opportunity. Examples of Enablement include remote control over electronic devices, individualised assistance to employees in relation to their working space, facilitation of late-night workers to a central office area, changes in custodial practices (offering buildings managers more control over energy systems) and participation in governance of the organisation. It is an area ripe for further research, particularly in relation to notions of control and responsibility conferred by enabling interventions, which are currently under-researched. Indeed with regards to employee engagement in general, interventions which incorporate social influences appear to be generally most successful. Modelling, peer-education, public

[3] As discussed further below (see Section 3.2), Capability refers to an individual's psychological and physical capacity to engage in the activity concerned, whilst Opportunity refers to the factors that lie outside of the individual that make the behaviour possible or prompt it.

and social incentives, and social persuasion all tend to be associated with successful interventions. We discuss further below (see Section 4.1) the particular context of workplaces for such social influences.

Environmental Restructuring interventions, in particular automation of technologies also hold great potential for energy saving interventions. Whilst these technologies do not aim to induce changes in behaviour they appear to create a new context in which energy saving behaviour can take place. The negotiation with and acceptance of new technologies by employees has been little researched to date but is worthy of further investigation.

3.2. The importance of different 'Sources of Behaviour'

In the BCW the Intervention Functions (discussed above in Section 3.1) are positioned around a central hub containing three Sources of Behaviour: Capability, Opportunity and Motivation. Note that the positioning within the BCW does not reflect associations between the wheel rings but that particular Sources of Behaviour are linked to (and supported through) different Intervention Functions (Table 2). Capability, Opportunity and Motivation have already been defined above but it is important to acknowledge that each has two sub components: Capability refers to *Physical* and *Psychological* aspects of an individual's capacity to engage in the behaviour concerned, Motivation refers to *Automatic* and *Reflective* brain processes that energize and direct behaviour, and Opportunity refers to external factors that are *Physical* and *Social* factors in and which supporting the behaviour [54,p.4]. Having categorised the methods used in the reviewed studies according to the nine Intervention Functions (Section 3.1), we now go on to relate these to the three Sources of Behaviour (and their sub components) to explore which are associated with the most successful interventions.

Interestingly, what sets apart the most successful Intervention Functions adopted in workplace energy saving interventions i.e. Enablement, Environmental Restructuring and Modelling, from the others is their correspondence with Opportunity (both Social and Physical), indicating that these may be particularly useful drivers of behaviour to target within interventions. None of the less successful Intervention Functions contribute to or provide either Social or Physical Opportunity. Interestingly Social Opportunity is related to the concept of 'social influences' [53, p.113, Table 2]—already noted as a common feature in successful interventions [2]. Social influences are interpersonal influences that can have an impact on the way that individuals perceive a situation or behaviour and encompass processes including social pressure, norms, conformity, and comparisons.

With regards to Physical Opportunity, this Source of Behaviour is related to theoretical ideas of 'environmental context and resources' [53, p.113, Table 2]. As discussed above (see Section 3.1.7), whilst behaviour change programmes aim to alter employee actions in relation to their use of energy, changes in physical infrastructure and technologies are often integral to successful reductions. Much remains to be understood about how technologies are accepted and negotiated by employees however, and about their shorter and longer-term impacts on employee behaviour, motivations and willingness to engage in energy savings.

4. Discussion

4.1. Saving energy in the workplace

The communal nature of most workplaces, in that they bring together multiple employees and involve hierarchical management structures, tends to be what sets them apart from domestic settings. Social and group norms and dynamics within an organisation have been shown to be important in increasing employee motivations to act [8,10,12,47,79] and this supports findings presented here which also demonstrate how interventions can serve to create new norms and standards regarding energy use in the office. Previous research suggests that interventions should target employees based on their pre-existing groupings [8] and that a sense of community is important in motivating energy saving behaviours at work [4]. The studies reviewed here did not consider – or at least did not detail – all of these things, but they did find that peer-education and modelling of particular employees held potential. Personal contact and communications between colleagues with regards to possible energy saving actions can thus alter behaviours. Much effort has gone into researching the effectiveness of providing feedback on energy use behaviour, suggesting that in communal settings, such as the workplace, providing feedback on a group basis is more effective than that delivered individually [11,61]. Findings synthesised here also suggest that whilst the information provided through feedback can be important, the manner in which such information is presented is equally significant. Rewards and incentives given publically (rather than privately) are also more likely to be effective, reflecting the importance of social influence.

4.2. Methodological considerations

Our review is limited by the relatively small number of papers available to review, and our conclusions hinge on their quality. Many of the studies made use of self-report questionnaires with participants, typically pre- and post-intervention to gain an understanding of (changes in) behaviour, behavioural intentions, attitudes, values and identities. Such self-report questionnaires have been criticised for reporting, for example, what people *say* they will do rather than what they *actually* do in practice [50]. Converged with actual energy saving data, self-report questionnaires are important in order to reveal the underlying drivers for behaviour change. We highlight that comparing metrics of success has considerable problems; whilst some studies measure this through digital technologies (i.e. smart meters), others use electricity bills which it is observed makes detecting savings of less than 10% difficult to discern from background variation [50]. In addition, when assessing energy use, some studies control for changes in the weather whilst others do not. The length of interventions, and of research into those, also varies; the majority studies are relatively short term (most examine a few weeks or months), leaving the medium to long-term effects of interventions unknown. A number of studies question the wider applicability of their findings as they are based on organisations involved in sustainability or in which employees already demonstrate strong pro-environmental attitudes prior to any behaviour change intervention. The studies also represent a fairly homogenous group of workplace environments (individual or open-plan offices, often in Universities, and almost all in the global North) meaning much remains to be understood about the complexity and global diversity represented within the seemingly simple category of non-domestic buildings.

Details provided on the length of study and numbers of participants vary, with studies of holistic employer-led behaviour change programmes typically containing fewer details than trials led by academics, limiting the understanding gained from the findings. The focus and breadth of studies also varies, with academic trials tending to focus on fewer elements of intervention but able to provide greater depth in their assessment of it, whilst employer-led holistic programmes tend to include multiple elements which can be viewed interacting with each other, but with less ability to attribute energy savings to any particular element(s).

Table 2
Matrix of links between Intervention Function and Sources of Behaviour (Capability, Motivation and Opportunity) in the Behaviour Change Wheel [53] (for definitions of Intervention Functions see Table 2 and of Sources of Behaviour see main text, Section 3.2).

	Capability		Motivation		Opportunity	
Intervention	Physical	Psychological	Reflective	Automatic	Physical	Social
Education		■	■			
Persuasion			■	■		
Incentivisation			■	■		
Environmental restructuring		■		■	■	■
Modelling		■	■	■		■
Enablement		■	■	■	■	■
Intervention Functions below are NOT represented in the studies reviewed in this paper but are included here for comprehensiveness						
Coercion			■	■		
Training	■	■		■	■	
Restriction					■	■

4.3. Recommendations for future research

Our review finds that three forms of intervention have not been investigated at all to date; Coercion, Training and Restriction. Though we acknowledge there may be important reasons why, in certain contexts, these may not be appropriate or advantageous, a recent meta-analysis of pro-environmental behaviour studies finds that the most successful interventions are often the least studied [24] indicating that these gaps in the literature deserve attention.

Our analysis has highlighted interventions characterised as involving Enablement, Environmental Restructuring, and those including aspects of social influence as particularly successful. It is notable that our analysis highlights the importance of creating physical opportunities to save energy, either through automation or retrofit of technology, or through digital displays and devices to provide information and advice on energy use. Whilst some technological solutions may not directly aim to change employee behaviour they certainly create a new context in which behaviour takes place. Far greater understanding is needed of the ways in which employees interact with this technology to understand the aspects of these interactions that lead to actual behaviour change. We propose that further research is needed in order to drill down to understand which elements of these interventions types are most important in the context of energy savings and when and how these are successful. Certain interventions often appear to overlap with each other (e.g. Incentivisation and Modelling) and it is important to understand which aspects are driving behaviour change, though we also highlight that it is possible that certain intervention aspects may work best in interaction with one another.

There is a clear need for more systematic studies which aim to more conclusively identify successful factors – or combinations of factors – in producing behaviour change. Abraham and Michie [81] highlight the importance of assessing the individual and combined effectiveness of techniques used in behaviour change interventions in the health sector and we propose the same is needed within energy saving interventions. Our review finds that there is a lack of common definitions of techniques and methods amongst interventions to change energy-use behaviour in the workplace, as well as inconsistencies in the ways in which these are discussed and assessed (cf. the health sector: [81]). This problem may indeed be particularly pronounced in this field given the range of disciplines, and indeed organisation types, conducting research in this area. We propose that further research in this area provides more depth of description of not only the interventions conducted, but also the sampling and procedures utilised, in order to better allow for replication and the analysis of reasons of failure and success. Notably, with regards to sampling, more attention should be paid to all employees within an organisation, with more focus given to those choosing *not* to participate in interventions to understand their reasons why.

We propose that interventions conducted should be based on a theoretical framework, rather than just practical considerations, so that the reason for resulting behaviours can be fully understood. In particular, it is important to evaluate changes in perceptions and psychological factors alongside changes in energy use so the driving factors for change, or indeed barriers to action, can be better understood. Studies should also consider more longitudinal research that explores which interventions create long lasting impacts. This provides not only valuable theoretical insight into drivers of change but also some indication as to the useful length of campaigns and frequency with which they should be conducted.

Much remains to be understood about the influence of the workplace as a context for potential energy saving behaviours. Behaviour change interventions operate within the context of competing organisational, institutional and political priorities and it is against this backdrop that the potential for interventions to achieve change must be understood [45]. Many of the studies reviewed in this paper focused their analysis on the energy savings generated and the efficacy of the intervention tools employed, rather than the wider workplace context, leaving another significant gap for future research. Differences between public and private sector workplaces need to be explored, as do those between big and small companies, or those from different parts of the world, or in relation to long-serving or short-term employees. Such contexts may influence feelings of responsibility, control, trust and privacy amongst employees, as well as issues of staff relations, productivity, budgets and trade union activity, all of which are important in understanding the potential for energy savings within the workplace [45]. The influence of local, national and international policies on the potential to save energy in the workplace also deserves attention [3].

5. Conclusions

This paper set out to identify what types of behaviour change intervention are most successful at saving energy in an office-type workplace (offices in public and private buildings, universities and schools). It did so through an extensive literature review which identified 22 studies of energy saving intervention in offices from around the world, and a synthesis and analysis of these through

the Behaviour Change Wheel [53,54]. We found that interventions which create social and physical opportunities for employees to save energy are the most successful, namely those which constitute Enablement (including direct support and greater control to employees), Environmental Restructuring (particularly automated technologies) and Modelling (various forms of social influence). Given the clear importance of governance and culture noted within Modelling interventions, and the potential for process changes noted within Enablement interventions, our findings indicate that energy savings in the workplace depend not only on the individual and collective actions of employees, but importantly also on the attitudes and engagement of management, on wider organisational change, and on investment in energy efficient technology. The communal nature of most workplaces demands further scrutiny in order to understand how social influences condition individual and collective actions, including around the negotiation and adoption of new energy technologies. We provide recommendations for future research, notably the need to consider forms of intervention not yet researched; Coercion, Restriction, and Training. We urge other researchers reporting on energy saving interventions to consider and measure the theoretical reasons behind energy saving behaviour, more systematically report and analyse their findings, and where possible to undertake further longitudinal evaluations; this will enable more accurate identification of those techniques which offer greatest success in saving energy and thus reducing carbon emissions.

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Appendix A. Systematic review process.

Choice of base keywords

ET (energy terms)

The review process (Fig. A1) involved searching for base keywords and combination keywords (Tables A1 and A2). Energy terms were selected to cover a comprehensive range of both energy use and conservation. The former was to ensure that current practices of energy use was current practices of energy use were included in the search, including those with or without the introduction of intervention programs. The term "Energy efficienc*" was selected to cover a range of papers including those relating to "energy efficient" and "energy efficiency". The energy conservation literature in organisational settings has also been concerned with broader pro-environmental concerns such as recycling, travel behaviour and printing behaviour in addition to energy conservation. Therefore, the terms "pro-environmental" and "green" behaviour was included in the search to retrieve studies that included energy conversation as a part of a programs to promote pro-environmental behaviours.

WT (workplace terms)

The purpose of focusing the search to the workplace was to find the gaps in literature in the workplace and commercial contexts. Hence we narrowed our search specifically to include workplace terms and not "domestic" studies. Workplaces were also referred to as organisations, offices and industries, which is reflected in the choice of keywords.

Choice of combination keywords

BT (behaviour terms)

Behaviour terms were the key words selected to identify behavioural change programs for energy conservation in the workplace. The keywords were developed out of reviewing several key papers in the area. For example; while conducting the preliminary searches of papers; we identified that the use of persuasion techniques is widely popular in energy conservation programs and led us to include this in the search query. Further; the use of the theory of planned behaviour in studies of behaviour change; prompting its inclusion in the queries (Table A1).

ES (energy systems)

Supporting energy intervention programs by adopting the design and use of technological systems is becoming increasingly popular and is evident in a growing number of recent intervention studies. Identifying this potential we framed a set of keywords to identify studies relevant to this (Fig. A1).

ST (social terms) & PV (personal variables)

While these terms were not directly associated with intervention programs, many of the papers discussed interventions targeted at changing attitudes and beliefs about energy conservation. Thus in order to ensure that these studies were are not missed, we included these broader set of keywords in the search queries.

Formulation of queries

The way in which the searches were executed was to combine the base keywords along with a combination keyword queries (see Table A2 for description of search combinations).

1. **Base keywords AND combination keywords. For example**:

TITLE-ABS-KEY ("energy efficienc*" OR 'energy conservation' OR "energy consumption" OR "pro-environmental behav*" OR 'proenvironmental behav*" OR "green*" OR "sustain*" OR "energy use" OR 'energy reduction' OR "energy sav*") AND TITLE-ABS-KEY('commercial' OR "workplace*" OR "office*" OR "organi*ation*" OR "compan*" OR "business*" OR "industr*")) AND TITLE-ABS-KEY(interven* OR behav* change OR behav* interv* OR behav* program* OR technique* OR persuas* OR reward* OR theory of planned behav*) AND PUBYEAR > 1999 AND (LIMIT-TO(LANGUAGE, "English'))

Applying Inclusion and Exclusion Criteria

Papers that were shortlisted from the larger results were further subjected to the criteria discussed below.

Inclusion criteria:

1. Papers reporting on Workplace Energy Conservation/Intervention Programs.
2. Papers published in English.
3. Papers published after 2000.

Exclusion criteria:

1. Papers reporting on Energy Conservation programs in Domestic Contexts.
2. Papers reporting on other pro-environmental behavioursexcluding energy behaviours as a factor.
3. Papers in languages other than English.
4. Papers published before 2000.

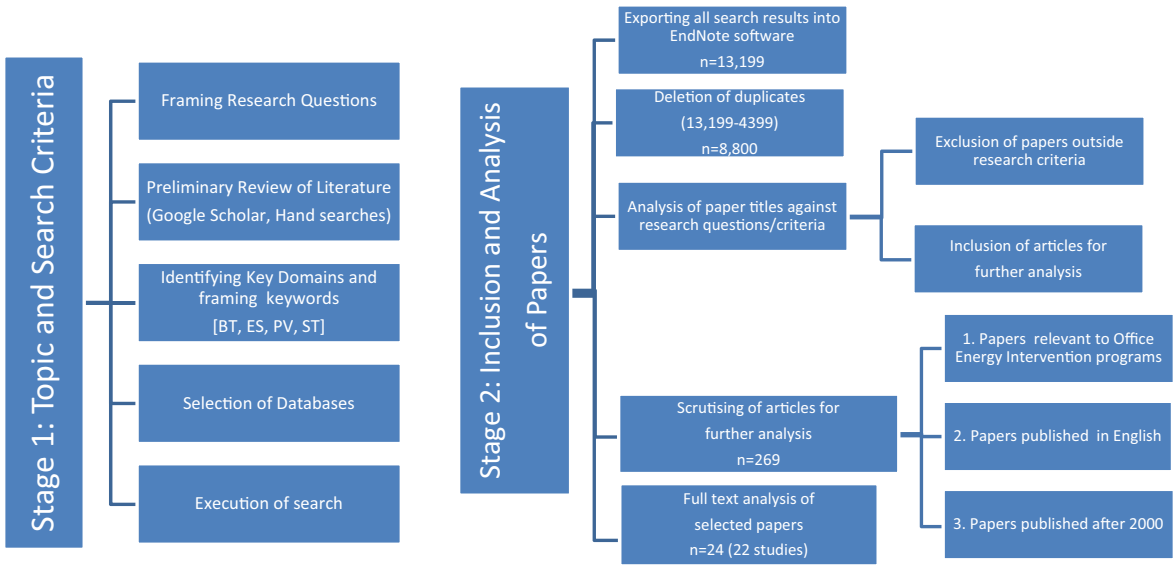

Fig. A1. Systematic review process.

Table A1
Description of terms.

Base keywords	
ET	Energy terms (“energy efficienc*” OR ‘energy conservation’ OR “energy consumption” OR “pro-environmental behav*” OR “proenvironmental behav*” OR “green*” OR “sustain*” OR “energy use” OR “energy reduction” OR “energy sav*”)
WT	Workplace terms (“commercial” OR “workplace*” OR “office*” OR “organi*ation*” OR “compan*” OR “business*” OR “industr*”)
Combination keywords	
BT	Behaviour Terms (interven* OR behav* change OR behav* interv* OR behav* program* OR technique* OR persuas* OR reward* OR theory of planned behav*)
ES	Energy systems (“energy feedback” OR “feedback” OR “energy display*” OR ‘eco feedback’ OR “smart meter*” OR “energy system*”)
PV	Personal variables (“value*” OR “attitude*” OR “affect” OR “barrier*” OR “motiv*” OR “spillover*” OR “knowledge” OR “understanding” OR “belief*” OR “habit*”)
ST	Social Terms (ST) (“social dimension*” OR “norm*” OR “people” OR “experienc*” OR “routine*” OR “practice*”)

Table A2
Search combination matrix.

Energy terms (ET)		Workplace terms (WT)	AND	Results[a]
(“energy efficienc*” OR ‘energy conservation’ OR “energy consumption” OR “pro-environmental behav*” OR “pro environmental behav*” OR “green*” OR “sustain*” OR “energy use” OR “energy reduction” OR “energy sav*”)	+	(“commercial” OR “workplace*” OR “office*” OR “organisation*” OR “compan*” OR “business*” OR “industr*”)	Behaviour terms (BT) (interven* OR behav* change OR behav* interv* OR behav* program* OR technique* OR persuas* OR reward* OR theory of planned behav*)	3619
			Energy systems (ES) (“energy feedback” OR “feedback” OR “energy display*” OR ‘eco feedback’ OR “smart meter*” OR “energy system*”)	2325
			Personal variables (PV) (“value*” OR “attitude*” OR “affect” OR “barrier*” OR “motiv*” OR “spillover*” OR “knowledge” OR “understanding” OR “belief*” OR “habit*”)	3746
			Social Terms (ST) (“social dimension*” OR ‘norm*” OR “people’ OR “experienc*” OR “routine*” OR “practice*”)	3509

[a] Indicates search results up to January 2016 before deletion of duplicates.

Appendix B. Brief introduction to the 22 studies reviewed in this paper.

Study	Authors	Disciplinary perspective	Intervention	Setting & sample	Evaluation
1	Carrico and Riemer [10]	Psychology	Trial involving feedback and peer education on energy use, measuring electricity consumption to power lights and appliances, heating & cooling	University employees in the USA, n = 352 employees (73% female, mean age 43, highly educated)	4 month baseline, 4 month intervention; pre- and post-intervention quantitative participant survey (exposure to intervention, self-reported conservation behaviour, perceived descriptive and injunctive norms, collective outcome expectancy beliefs, goal attractiveness); Energy consumption & outside temperatures recorded
2	Gustafason and Longland [48]	Psychology & Social marketing	Programme with multiple tactics to effect behavioural change around energy efficiency	Commercial employees (BC Hydro) in Canada, n = 184 employees surveyed (later scaled up to other offices)	Pilot study; pre- and post-intervention quantitative participant survey (self-report of attitude and behaviour changes); Energy consumption measured (electricity bill)
3	Handgraaf et al. [51]	Behavioural economics	Trial to assess effect of monetary vs. social rewards in altering computer energy use (through smart plug)	Commercial firm (involved in sustainable energy supply) employees in the Netherlands, n = 83 employees (46% female, mean age 36)	2 week baseline, 13 week intervention; pre- and post-intervention quantitative participant survey (self-reported conservation behaviours, experienced motivation to improve energy conservation scores, social interaction, manipulation comprehension levels); Energy consumption recorded (per hour)
4	Kuntz et al. [46]	Computer science (Gaming)	Programme involving game mechanics to reward participants for changes they make *outside* of the office, including household energy use (plus water usage, transportation, waste management, food choices), called iChoose	Construction firm in the USA, n = 230 employees (later scaled up to rest of company)	Pre- and post-intervention quantitative participant survey, with information also collected as part of the game
5	Murtagh et al. [50]	Psychology	Trial of individual feedback on plug load energy use at the work desk	University employees in the UK, n = 83 employees (22% female, mean age 33, range of jobs & grades)	4 week baseline, 18 week intervention; Pre- and post-intervention quantitative participant survey (self-reported pro-env behaviour, intention to use feedback application, attitude towards technology and energy saving, values, environmental identity); Energy consumption and provision of individual feedback on energy use; 2 focus groups post-intervention (one with participants who used the feedback application, one with those who didn't)
6	Owen et al. [49]	Social marketing	Programme to engage employees and use of energy information system (EIS), focusing on electricity usage at work stations and for lighting	Government ministry in Canada, for EIS (lighting) n = 200 employees, but unknown number in general programme	1 week EIS Lighting campaign during one year CBSM program; Government-tool 'SMARTTOOL' used to assess energy savings

7	Staats et al. [82]	Psychology	Trial of a simple, low-cost information interventions to target heat use (radiators grate coverings and thermostat settings)	University employees in the Netherlands, n = 384 offices	4 week intervention followed 1 year later by another 4 week intervention, with follow-up 1 year later (total 2 years); Quantitative observations in offices of radiator coverage and settings (inter-observer reliability calculated); Gas consumption measured; Short questionnaire for participants
8	Werner et al. [62]	Psychology	Programme involving brief group discussions to prompt students to reduce electricity use by turning-off classroom lights	University in the USA, n = 56 classrooms	Baseline 3 weeks, 5 week intervention; Quantitative observations of classrooms if unoccupied were lights on/off/partially on (inter-observer reliability calculated at 80%)
9	DECC [80]	Computer science (Gaming)	Programme using user-centred digital platform to engage employees on sustainability issues including energy use during late night working (plus food eaten for lunch, travel to work)	Public body (DECC) in the UK (responsible to government for energy), n = 1000 employees	Energy consumption measured
10	Metzger et al. [69]	–	Trial of plug load energy use for 'pods' of employees (6-8 people) through feedback, competition and automation	Commercial firm in the USA, n = 126 employees (across 4 floors)	4 week baseline; 4 week intervention, 4 week monitoring; Energy consumption measured
11a	Nye and Hargreaves [78]	Sociology	Programme of employee engagement ('Environment Champions') which included audit of utilities use at start and end (plus audit of waste)	Construction company in the UK, n = 16 'Champions' (50% female, mid-20s to late-50s, range of levels of seniority)	9 month programme including 5 month intervention; Interviews and focus groups with participants, participant observation during intervention
11b	Hargreaves [23]	Sociology	(ditto)	(ditto)	Interviews with participants, participant observation during intervention
12a	Schelly et al. [67]	Psychology & organisation studies	Programme of energy use reduction schools	School in the USA, n = 2 schools (1,700 students each)	Long-term programme with 7 years of energy data collected; Post-hoc study with interviews and focus groups with participants; document review; Energy consumption measured
12b	Schelly et al. [68]	Psychology	(ditto)	(ditto)	(ditto)
13	Yun [75]	–	Trial using energy dashboard to provide 1) feedback, 2) remote control, and 3) automated control to employees	Pilot study in the USA in University and government research facility, n = 22 employees	1 month pilot trial; Plug-load electricity use measured
14	Aga-Hossein et al. [63]	Psychology (theories of persuasion)	Trial involving interactive poster to persuade office employees to use the stairs instead of lift	Office employees in UK, n = 600 employees (mostly engineers)	Poster in place for 2 weeks; data collected on stair usage (counter beam) and lift usage (sub-metering of electricity consumption) 2 weeks prior to installation of poster as baseline, for 2 weeks it was in place, and for 2 weeks after its removal; Pre- and post-intervention quantitative employee survey to gauge perceptions and attitudes on sustainability; Interviews with 16 employees post-trial to evaluate experiences

15	Orland et al. [70]	Computer science (Gaming)	Trial involving on-line 'serious game' to reduce plug-load energy use called 'Energy Chickens'	Medium-sized commercial office in the US, n = 57 participants (51% female, mean age 47, 82% white) – 41 played the serious game + 16 exposed to poster	Plug-load energy use monitored for 5 week baseline, and throughout trial; combination of serious game and poster used for 8 weeks; poster removed but game continued for another 6 weeks; game stopped but followed by 8 week follow-up period of plug-load monitoring only
16	Tolias et al. [71]	Computer science (Gaming)	Trial involving pervasive game on smart phones and computers to reduce 'idle-time' on computers i.e. time of no activity, called IdleWars	Medium sized office in the UK, n = 20 participants (55% female, age range mostly in 30s, highly educated)	Game used for 2 weeks; Idle-time on computers was monitored throughout; Focus group with 8 employees post-trial to evaluate experiences
17	Dixon et al. [47]	Psychology	Programme to provide comparative feedback on energy usage between employees of different buildings	University in the US, n = 6 buildings, n = 2,112/1,601 pre/post survey respondents (positive pre-intervention pro-environmental attitudes)	Pre- and post-intervention quantitative participant survey (conservation-related subjective norms, perceived behavioural control, attitudes, self-reported behaviour); building energy consumption measured
18	Craig and Allen [60]	–	Programme of curriculum-based learning on environmental literacy and energy-saving behaviours	School in the US, n = 63 student participants (8–9 year olds)	6 month intervention with year-long energy analysis; pre- and post-intervention participant survey; school and student's home energy consumption measured;
19	Kamilaris et al. [61]	–	Trial to monitor occupants energy use and provide individual feedback through emails, posters and leaflets	University in Singapore, n = 18 participants (22% female, age range mostly 36-45 (33%), most manage-rial/supervisory (50%))	5 week baseline, 5 week intervention (feedback provision through email, posters and leaflets), and 13 week monitoring phase; post-intervention participant survey; computer electricity use measured throughout
20	Nilsson et al. [79]	Psychology	Trial with 3 conditions; control, intervention (goal-setting, feedback, information, prompts), intervention + group-identity manipulation	Private company in Sweden, n = 93 employees (in 3 departments, 23% female, average age 44)	2 weeks baseline, 4 week intervention; pre- and post-intervention participant survey; electricity use in office sockets measured; observation data collected (computers left on/off observed at set times)
21	Yun et al. [76]	–	Trial to assess Intelligent Dashboard for Occupants (ID-O), manual (remote online) and automatic controls for office devices	Office type not given, in the US, n = 80 employees	27 week study; post-intervention participants survey; 4 plugwise devices installed at each work station to monitor electricity use (for laptops, monitor, phones, desk light)
22	Jaramillo Garcia et al. [77]	–	Trial to assess dynamically adaptive proximity controller (APC) to detect desk activities and turn computer screen on and off accordingly	University in the Netherlands, n = 12 participants (age 24-45)	11 day baseline and 8 day intervention; pre- and post-intervention participant survey; plug-in power meter used to measure computer screen electricity use

Appendix C. Details of the studies reviewed in this paper according to the Intervention Functions of the Behaviour Change Wheel (definitions are given below; Michie et al., 2014, p.111 [53]).

Study	Education	Persuasion	Incentivisation	Coercion	Training	Restrictions	Environmental restructuring	Modelling	Enablement
Carrico and Riemer [10] (study 1)	1. Feedback on energy use 2. Peer education 3. Instructions given	1. Feedback in graphs and encouraging text	1. Goal setting (of energy reductions)	[Keen NOT to use negative reinforcement]					
Gustafason and Longland [48] (study 2)	1. Communication of messages, information 2. 'Lunch & Learns' 3. 'Turn It Off' stickers & posters	1. Ethos of commitment and can do attitude	1. Expectations of social rewards 2. 'Floor Challenge' 3. Meeting goals set impacts employee bonus 4. Prize for 'Floor Challenge' 5. 'Lunch & Learns' provide food	[Keen NOT to use punishment or blame]			1. 'Turn It Off' stickers & posters	1. 'Conservation Champions recognition programme 2. 'Floor Challenge'	1. 'Cubicle clean-ups' (at work station)
Handgraaf et al. [51] (study 3)	1. Emailed weekly 'Personal energy savings report'	1. Descriptive comments given (as part of social reward)	1. Monetary reward 2. Social reward				1. Emailed weekly 'Personal energy savings report'	1. Comparison with colleagues (as part of public reward)	
Kuntz et al. [46] (study 4)	1. Deck of cards given with energy saving actions		1. Monthly cash prize for individuals 2. Game end prize for teams				1. Deck of cards given with energy saving actions	1. Participants share stories and photos of actions 2. "Opportunities for bragging" made available	
Murtagh et al. [50] (study 5)	1. Feedback on energy use 2. Hints on saving energy	1. MyEcoFootprint displays red/amber/green 2. Graphs and tables of energy use					1. MyEcoFootprint gadget	1. Comparison with the office average	
Owen et al. [49] (study 6)	1. Checklist of actions to do 2. Information given on actions to reduce lighting energy use 3. Feedback on energy use 4. Results provided at end of intervention	1. 'Green Pledge' taken by employees 2. 'Pulse Energy' software used to give visual feedback on lighting through dashboard 4. Information provided in the lobby with graphs of results 5. Email prompts for 'Earth Hour' style event 6. Focus on changing norms through displays and actions	1. Prizes for 'green' business improvement suggestions 2. Prizes for completing 'Work Station tune ups' 3. Goal setting (10% savings through lighting EIS)				1. 'Energy Information System' (EIS) – retrofit for automatic daylight dimming system for lights, plus power meters 2. 'Pulse Energy' software – tool for visual feedback 3. 'Turn It Off' stickers 4. Email prompts for 'Earth Hour' style event 5. Focus on changing norms through displays	1. 'Energy Champions' – profiling champions on each floor who exemplified conservation behaviour	1. 'Work Station tune-ups'
Staats et al. [82] (study 7)	1. Feedback on first intervention phase results 2. Poster with information on energy saving actions	1. Collective feedback at display boards with graphic displays 2. Brochure with requests for energy saving actions					1. Poster with prompts for energy saving actions 2. Collective feedback at display boards		
Werner et al. [62] (study 8)	1. Signs to turn lights off 2. Presentations giving information	1. Signs with images to engage user and make them feel personally responsible 2. Presentations asking classroom users personally to turn off lights					1. Signs by light to turn them off		
DECC [80] (study 9)	1. Information on moving to one area to work late ('Scrunch')	1. Real-time energy displays for feedback 2. Pledges	1. Games with points and prizes (e.g. 'Scrunch' provides food)					1. Sharing stories	1. 'Scrunch' promotes employees moving to one area to work late

Metzger et al. [69] (study 10)	1. Information on plug-loads and energy conservation tips		1. Competition between groups of colleagues through public feedback (no reward mentioned)		1. Automated control system (switch off non-essential circuits when pod empty for 15 minutes) 2. Online digital dashboard to display energy savings	1. Competition between groups of colleagues	
Nye et al. [78], Hargreaves [23] (study 11)	1. Feedback on energy use from audit 2. Poster with pro-environmental message 3. Email 'leave the office checklist'	1. Feedback from the audit created feeling of personal responsibility	1. Goal setting for the team		1. Poster with pro-environmental message 2. Email 'leave the office checklist'	1. Volunteer Champions	
Schelly et al. [67,68] (study 12)	1. Email reminders to turn off lights and computers 2. Signs to turn lights off 3. Verbal communication about energy conserving actions 4. Results of energy saving actions communicated through newsletter, announcements, emails, posters	1. 'Ethic of Sustainability' articulated 2. Email reminders motivated teachers 3. Visual cues through art work on bins 4. School mottos used as vehicle to promote sustainability 5. Graphs used in energy saving results feedback			1. Centralised controls for heating and air-conditioning 2. Replacement of lights to more efficient ones 3. Automating shut-off in computer lab 4. Signs to turn lights off 5. Email reminders motivated teachers 6. Newsletter, announcements, posters	1. Of school Principle, of teachers and of students	1. 'Custodial practices changed e.g. when lights routinely turned on and off 2. Course offerings in relation to sustainability 3. Participation in school governance by custodians and students 4. Energy savings spent (by students) on purchasing wind energy every year
Yun [75] (study 13)	1. Feedback of self-monitoring 2. Advice given				1. Automation controls 2. Dashboard to display energy usage	1. Comparison with colleagues	1. Remote control of plug-load devices
Aga-Hossein et al. [63] (study 14)	1. Poster providing feedback	1. Persuasive imagery used			1. Poster placed in key position by stairs/lift		
Orland et al. [70] (study 15)	1. Poster used to give advice		1. Serious game 2. Rewards given for participation		1. Posters 2. On-screen game	1. Comparison with colleagues	
Tolias et al. [71] (study 16)	1. Feedback provided on plug-load		1. Pervasive game		1. On-screen game	1. Comparison with colleagues	
Dixon et al. [47] (study 17)	1. Results of energy saving communicated through email, website, posters	1. Persuasive imagery and language used			1. Software tool for feedback 2. Email messages 3. Website information 4. Posters	1. Comparison with colleagues	
Craig and Allen [60] (study 18)	1. Assembly discussion 2. Classroom activities 3. Signs and posters 4. Information sent through Newsletter				1. Stickers and posters around school and home	1. Strong champion in District Energy Manager'	1. Students given control over setting thermostats at school
Kamilaris et al. [61] (study 19)	1. Advice and information through posters, leaflets and email		1. Goal-setting through posters, leaflets and email		1. Device to monitor computer use	1. Comparison with colleagues through poster, leaflets and email	
Nilsson et al. [79] (study 20)	1. Prompts 2. Feedback by email	1. Prompt design 2. Display of feedback	1. Goal-setting			1. Group identity manipulation	
Yun et al. [76] (study 21)	1. Feedback through ID-O	1. ID-O design			1. Intelligent Dashboard for Occupants (ID-O) 2. Online remote (manual) controls 3. Automated controls	1. Peer-comparison through ID-O	1. Online remote (manual) control 2. Automated controls

Jaramillo Garcia et al. [77] (study 22)							1. Automated control		
No. of studies using each Intervention Function	21	14	12	0	0	0	19	17	7

Definitions of Intervention Functions (examples based on health-promoting activities):

- **Education** Increasing knowledge or understanding e.g. providing information to promote healthy eating.
- **Persuasion** Using communication to induce positive or negative feelings or stimulate action e.g. using imagery to motivate increases in physical activity.
- **Incentivisation** Creating expectation of reward e.g. using prize draws to induce attempts to stop smoking.
- **Coercion** Creating expectation of punishment or cost e.g. raising the financial cost to reduce excessive alcohol consumption.
- **Training** Imparting skills e.g. advanced driver training to increase safe driving.
- **Restriction** Using rules to reduce the opportunity to engage in the target behaviour (or to increase the target behaviour by reducing the opportunity to engage in competing behaviours) e.g. prohibiting sales of solvents to people under 18 to reduce use for intoxication.
- **Environmental restructuring** Changing the physical or social context e.g. providing on-screen prompts for GPs to ask about smoking behaviour.
- **Modelling** Providing an example for people to aspire to or imitate e.g. using TV drama scenes involving safe-sex practices to increase condom use.
- **Enablement** Increasing means/reducing barriers to increase capability or opportunity e.g. behavioural support for smoking cessation, medication for cognitive deficits, surgery to reduce obesity, prostheses to promote physical activity.

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